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NOTES ON THE SYSTEMATICS AND BIOLOGY OF THE BITING MIDGE, *FORCIPOMYIA ELEGANTULA* MALLOCH (DIPTERA: CERATOPOGONIDAE)

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Abstract.—The immature stages of *Forcipomyia* (*Forcipomyia*) *elegantula* Malloch are described and illustrated for the first time. Adults are redescribed and illustrated, and all stages are compared with the closely related European species *P. pulchrithorax* Edwards. Biological notes are given on this species which was found breeding under the bark of dead cottonwood trees on Plummers Island, Maryland. The structure and function of the peculiar hygroscopic hairs of the larva and their defensive value against predators are discussed.

We are indebted to Theodore J. Spilman for the discovery, during June 1976 on Plummers Island, Maryland, near Washington, D.C., of a large population of the biting midge *Forcipomyia* (*Forcipomyia*) *elegantula* Malloch. Large numbers of all stages of this strikingly marked midge were found under the thick bark on the trunks of large cottonwood trees (*Populus deltoides* Bartram) that had been felled by resident beavers and had lain on the river bank for a year or more. The colonies of the midge lived in the layers of tissue-thin inner bark next to the cabium where there was enough moisture to support a copious growth of microorganisms. A complex and rich biota of coleopterous and dipterous larvae and Collembola fed on these microorganisms or preyed on the herbivores. Fungal spores appeared to make up the bulk of the gut contents of the *Forcipomyia* larvae.

Malloch (1915) described *Forcipomyia elegantula* from adults collected at his laboratory window in Urbana, Illinois. Nothing has since been reported on this species. It is very similar to the Palearctic *F. pulchrithorax* Edwards (1924), described from specimens bred from wood debris and from sap flowing from wounds of elm and chestnut trees in England. Saunders (1924) described the immature stages of *F. pulchrithorax* and the species has since been reported from Hungary, Belgium, Germany, and Estonia. We take this opportunity to present for the first time descriptions and illustrations of the immature stages of *F. elegantula*, figures and redescriptions of the adults and comparisons of all stages with those of *F. pulchrithorax*.

We are especially indebted to Ethel L. Grogan for preparing the illustrations. We also extend thanks to M. E. Taylor for aid in preparing the scanning electron micrographs. The junior author carried on the field work on Plummers Island during the summer of 1976 with financial support from a research grant from the Washington Biologists' Field Club.

Forcipomyia (*Forcipomyia*) *elegantula* Malloch
(Figs. 1–4, 6, 12–20)

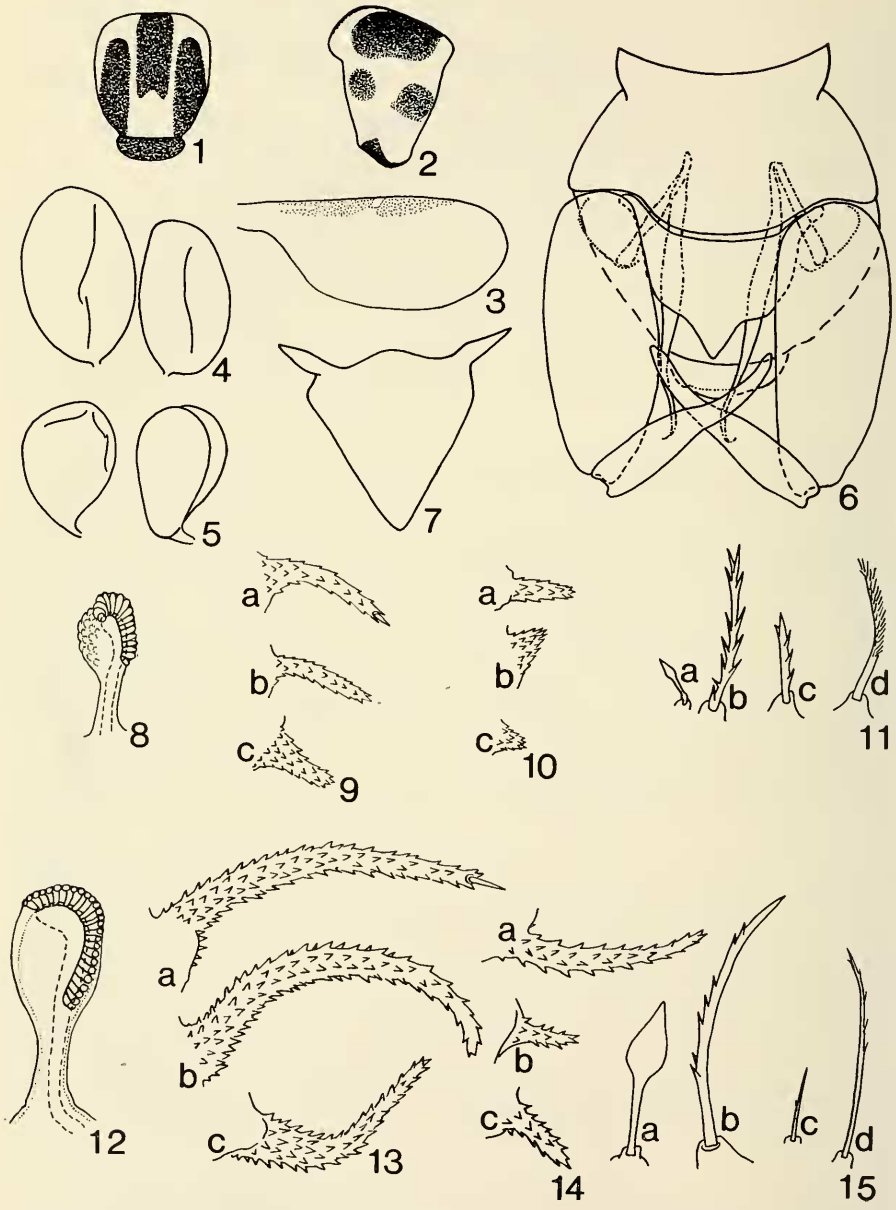
Forcipomyia elegantula Malloch, 1915:311 (male, female; Illinois); Johannsen, 1952:157 (in key to spp. NE USA).

Forcipomyia (*Forcipomyia*) *elegantula* Malloch; Johannsen, 1943:777 (in list N. Amer. spp.); Wirth, 1965:125 (USA distribution).

Diagnosis.—A large yellowish species most closely resembling the Palaearctic *F. pulchrithorax*; distinguished from all other Nearctic *Forcipomyia* (*Forcipomyia*) by the following combination of characters: Adults with 3 black stripes on scutum and 2–3 black spots on pleuron; hind femur with black band on distal ¼; tibiae of female with hastate setae. Females differ from *F. pulchrithorax* in having a black band on hind femur and oval rather than pyriform spermathecae; males differ from that species in having a shield-shaped aedeagus with a concave basal arch and pointed tip, the aedeagus of *F. pulchrithorax* being triangular with a convex basal arch. Pupa with respiratory horn with reticulate surface and 25–30 spiracular papillae, and much shorter thoracic and abdominal processes than in *F. pulchrithorax*. Larva with large hastate *a* hairs; *a* hairs smaller and only slightly hastate in *F. pulchrithorax*.

Female.—Wing length 1.45 mm; breadth 0.60 mm. Head: Frontoclypeus, scape and pedicel of antenna yellow; vertex, flagellum of antenna, and palpus yellowish brown. Proximal 8 flagellomeres globose, possessing multiple sensoria; distal 5 elongate, lacking sensoria; apical flagellomere with distinct apical papilla; flagellomeres with lengths in proportion of 18-14-15-15-15-15-15-15-21-21-21-22-29; antennal ratio 1.07. Palpus with segments in proportion of 11-13-32-17-11; 3rd segment expanded basally with distinct deep pit bearing numerous minute sensilla; palpal ratio 2.46. Mandible reduced. Thorax: Yellowish. Scutum (Fig. 1) with 3 black stripes, the median 1 bifid posteriorly; scutellum and postscutellum black; pleuron (Fig. 2) with 2–3 round black spots, black stripe on sternum. Legs yellow; hind femur with black band on distal ¼; tibiae with large hastate setae; femora and tibiae with long setae. Wing about 2.5× longer than broad, covered with dense macrotrichia; pattern (Fig. 3) with lightly infuscated area on and distad of costa; costal ratio 0.45. Halter stem pale, knob white. Abdomen: Yellowish; terga and last 3 sterna brown, giving abdomen a banded appearance. Spermathecae (Fig. 4) oval, subequal with very short necks.

Male.—Similar to female, differing as follows: Flagellar plume brown; tibiae lacking hastate setae; wing more slender. Genitalia: As in Fig. 6. Ninth sternum about 2× as broad as long; caudomedian margin convex; 9th tergum tapered distally, posterior margin rounded, cerci very reduced. Basistyle nearly straight, 2.5× longer than broad; dististyle curved slightly



Figs. 1–15. *Forcipomyia elegantula* (Figs. 1–4, 6, 12–15) and *F. pulchrithorax* (Figs. 5, 7–11). 1. Color pattern of scutum; 2. Color pattern of pleuron; 3. Color pattern of female wing; 4–5. Spermathecae; 6. Male genitalia; 7. Aedeagus; 8, 12. Pupal respiratory horn; 9, 13. Thoracic processes of pupa; 10, 14. Abdominal processes of pupa; 11, 15. Abdominal hairs *a*, *b*, *c*, *d* of larva.

distally, 0.67× length of basistyle, tip darkened and slightly pointed. Aedeagus lightly sclerotized, shield-shaped; basal arch concave; basal arm short with rounded, slightly recurved tip; distal portion with pointed tip. Claspettes divided, lightly sclerotized; basal arm thickening slightly distally; distal portion slender, tapering distally with slightly recurved tip.

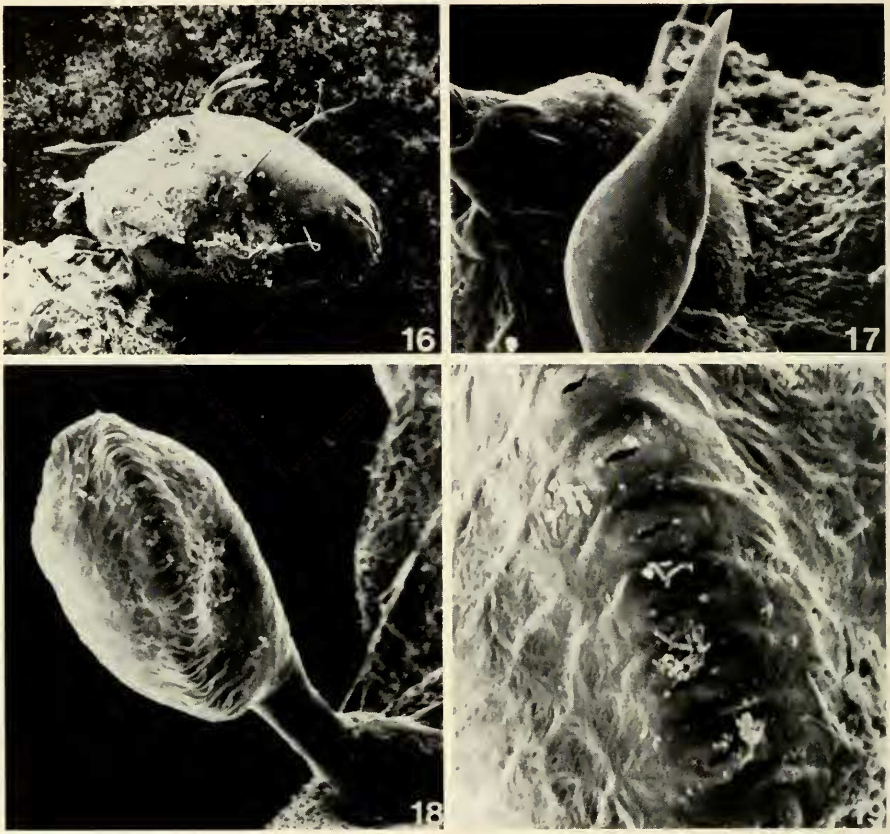
Pupa.—Retains larval exuviae. Respiratory horn (Fig. 12) with broadened base, narrowed proximally, then much broader distally; scanning electron micrograph reveals that surface is reticulate (Fig. 18), reticulations not visible in slide-mounted specimens; apex with 25–30 spiracular papillae; scanning electron micrograph reveals that apertures of papillae are much reduced (Fig. 19). Thorax with 4 pairs of dorsal setose thoracic processes; anterior pair (Fig. 13a) with terminal seta; 2nd and 3rd pair (Fig. 13b) similar but lacking terminal seta; 4th pair (Fig. 13c) similar to 2nd and 3rd but shorter; also a pair of short setose posterior processes present (not figured). Abdomen with a pair of long setose dorsal processes (Fig. 14a); a pair of short setose dorsal processes (Fig. 14b); and a slightly longer pair of setose lateroventral processes (Fig. 14c). Female terminal segment 1.6× longer than broad; surface covered with scattered fine-pointed tubercles; apicolateral processes appressed, surface wrinkled. Male terminal segment 1.6× longer than broad; surface smooth; apicolateral processes greatly appressed, surface wrinkled; ventral genital processes appressed, greatly wrinkled.

Larva (4th instar).—Body golden yellow, lightly sclerotized; internal structures of head sclerotized. Scanning electron micrograph of head (Fig. 16) indicates chaetotaxy as follows: *p* hair with broadly hastate tip; *q* hair similar to *p* hair but hastate tip slightly narrower; *t* hair long, slender; antenna 3-segmented. Prothoracic pseudopod entire; apex with 4 pairs of long sclerotized, slightly curved hooks. Midabdominal segments with hyaline, broadly hastate *a* hairs (Fig. 15a) connected dorsally by a narrow sclerotized bar to the *a* hair of the opposite side; *b* hair (Fig. 15b) heavily sclerotized, anterior sides branched; *c* hair (Fig. 15c) very short, branched on anterior side; *d* hair (Fig. 15d) twice as long as *c* hair, slightly branched on anterior side; surface of segments covered with small pointed tubercles. Terminal segment small; anal blood gills short, hyaline; anal pseudopod with double row of sclerotized hooks, 8 on each side.

Type.—Holotype, ♀, allotype, ♂, Urbana, Champaign Co., Illinois, 28.vi. and 5,12.viii.1915, on window in basement of Natural History Building, J. R. Malloch. Through the courtesy of Donald W. Webb the types were borrowed from the Illinois Natural History Survey and the allotype male was mounted on a slide for examination of the genitalia. The Plummers Island adults agreed in all respects with the types of *F. elegantula*.

Distribution.—Alberta and Saskatchewan south to Mississippi and east to Maryland; locality records plotted in Fig. 20.

New records.—ALBERTA: Medicine Hat, 30.viii.1949, L. G. Saunders,



Figs. 16–19. Scanning electron micrographs of *Forcipomyia elegantula*. 16. Larval head, 150×; 17. Abdominal *a* hair of larva, 1,150×; 18. Pupal respiratory horn, 550×; 19. Enlarged view of spiracles of pupal respiratory horn showing extremely small apertures of spiracular papillae, 2,100×.

all stages, reared from sap of black poplar tree. DISTRICT OF COLUMBIA: 3.vi.1935, A. Stone, 1♀ (pinned). KANSAS: Riley Co., ix,x.1964, N. Marston, malaise trap, 1♂, 1♀. MARYLAND: Montgomery Co., Plummers Island, 3.vi.1976, T. J. Spilman; 10.vi.1976, Wirth and Grogan; 17.vi.1976, Grogan, all stages. MISSISSIPPI: Washington Co., iv.1962, R. H. Roberts, light trap, 1♂. SASKATCHEWAN: Saskatoon, 3.ix.1950, L. G. Saunders, ex tree sap, 2♀, 1 larva, 1 pupa.

Biology.—We reared adults from pupae collected 3,10,17.vi.1976 on Plummers Island. A second generation may occur later in summer as Malloch collected specimens in Illinois in late June and again in August. The second generation would then have approximately two months to develop

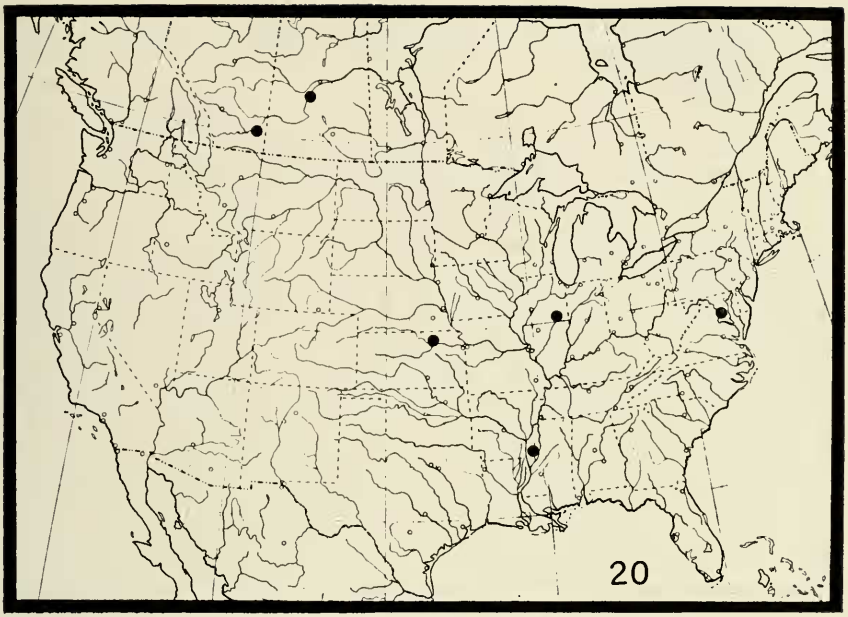


Fig. 20. North American locality records of *Forcipomyia elegantula*.

and offspring would probably be able to develop to third or fourth instars before overwintering.

We found pupae in circular aggregations of a dozen or more individuals. This behavior was observed by Saunders (1924) in many other species of *Forcipomyia* (*Forcipomyia*). Apparently during pupation they assemble in this circular manner with heads directed towards the center and tails outward. This behavior would seem to be evolutionarily disadvantageous for the species; those aggregating individuals being more or less an easily available concentration of food for any predators present. But when the larval structure and habits are studied more closely, the reason for this behavior becomes apparent.

Living larvae of *F. elegantula*, as in other species of the subgenus that have been observed, nearly always have conspicuous droplets of liquid on the tips of the hastate *a*, *p*, and *q* hairs of the body and head. According to Hinton (1955), Keilin (1918) was the first to comment on the biological significance of these modified hairs. Keilin "supposed that a hygroscopic substance on these hairs collected water from the atmosphere, which then wetted the cuticle and in some way facilitated respiration. Since the larvae are apneustic, the cuticle must be relatively permeable to air, and a hygroscopic film over the surface might be expected to tide the larvae over when exposed for short periods to lethal humidities. Keilin's explanation

of the function of the setae was repeated by Saunders (1924), and Keilin (1944) quotes Saunders as an authority for the view first published by himself" (Hinton, 1955).

Frew (1923) in a very detailed anatomical and histological study of the larva of *F.* (*F.*) *picea* (Winnertz), was apparently the first to confirm the secretory nature of the hastate body hairs of *Forcipomyia.* He reported (p. 436): "The dorsolateral and dorsal setae of the body are lodged over special hypoderm cells which are enormously hypertrophied. Their nuclei differ from those of ordinary hypoderm cells in having the chromatin scattered throughout the nucleus instead of concentrated round its periphery; they contain a large nucleolus. The dorsolateral setae have a central cavity extending almost to their tips, and this cavity is occupied by an axial protoplasmic filament given off from the basal cell. In the dorsal setae the central cavity extends right to the tip of the seta in the spear-shaped head of which it becomes somewhat enlarged, the whole cavity being occupied by a protoplasmic continuation of the basal cell. It is obviously this cell which secretes the drop of liquid found at the apex of each dorsal seta in the living larva. The large cephalic setae resemble the dorsolateral body setae. The remaining setae of the body are solid and are seated upon small thickenings of the hypoderm composed of several slightly hypertrophied cells instead of one greatly hypertrophied cell. The dorsal, dorsolateral and lateral setae of the body are attached to the body wall by distinct articulations, but this does not appear to be the case for the ventrolateral setae of the minute ventral setae."

Hinton (1955) gave details of a very interesting series of experiments performed by himself and his students to investigate the nature of the substance secreted through the specialized setae. They concluded that the substance is defensive in function and appears to have no significance in respiration. Using a laboratory colony of the ant *Lasius niger* L., they found that the ants would attempt to attack larvae of *Forcipomyia* (*F.*) *nigra* (Winnertz) when the latter were placed within their enclosure. Usually, whenever the ants came close enough to bite the midge larvae, they touched one or more droplets of liquid on the hastate setae, at which time they immediately dropped the larvae and usually spent several minutes cleaning themselves. Experiments at different relative humidities showed that at low humidities, when droplets were not formed, larvae were dorpped less quickly by the ants than at high humidities when the setae had large drops on their apices. If the last larval skins were removed from midge pupae, the ants would carry the pupae to their nest; they also succeeded in carrying away pupae if they could attack them from the front and dislodge them from the larval cuticle. But if the ants approached the pupae from the side or rear, they always became smeared with the hygroscopic substance remaining on the larval cuticle and would retire and clean themselves.

When the midge pupae form their usually complete circular aggregations, they form nearly a perfect defensive barrier against such attacks by predators. The chemical nature and mode of action of the hygroscopic substance remain a mystery.

Forcipomyia (*Forcipomyia*) *pulchrithorax* Edwards (Figs. 5, 7–11)

Forcipomyia pulchrithorax Edwards, in Saunders, 1924:209 (male, female; England; bred from larvae in tree sap, tree wounds, wood debris, etc.); Saunders, 1924:202 (larvae, pupae; from granular, solidifying sap from open wounds of elm, chestnut, and ash trees; figs.); Remm, 1961:173 (descriptive notes on male, female; figs.; Estonia); Goetghebuer, 1950:2 (Belgium; fig. male genitalia); Neindorff, 1959:31 (descriptive notes on all stages; habitat and life history notes; fig. wing; German); Zilahi-Sebess, 1940:21, 29 (Hungary; male, female redescribed; figs.); Havelka, 1976:232 (Germany; male, female diagnosis, figs.; seasonal distr.).

Diagnosis.—For detailed descriptions of all stages see Saunders (1924). *Forcipomyia pulchrithorax* is a darker species and differs from *F. elegantula* also in lacking the black band on distal ¼ of hind femur; females with pyriform spermathecae (Fig. 5); males with triangular aedeagus (Fig. 7) with a convex basal arch; pupa with a smaller tuberculate respiratory horn (Fig. 8) bearing 15–20 spiracular papillae, shorter thoracic processes (Figs. 9a–c) and shorter abdominal processes (Figs. 10a–c); larva with much smaller, slightly hastate *a* hair (Fig. 11a), shorter, stouter, doubly-branched *b* hair (Fig. 11b), stouter *c* hair (Fig. 11c), and shorter, stouter, fringed *d* hair (Fig. 11d).

Specimens examined.—AUSTRIA: Tirol, Igls, 900 m, 15.ix.1953, J. R. Vockeroth, 1♂. ENGLAND: Cambridge, 31.viii.1922, L. G. Saunders, from sap in elm wound, 1♀, 4 larvae, 5 pupae. ESTONIA: Luua, 28.viii. 1960, H. Remm, 1♂, 2♀.

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NOTE

REPLACEMENT NAME FOR *DROSOPHILA NIGRICOLOR* HARDY (DIPTERA: DROSOPHILIDAE)

Drosophila nigricolor Hardy (1977. Proc. Entomol. Soc. Wash. 79(1):92) is preoccupied by *D. nigricolor* de Meijere (1911. Tijdschr. Entomol. 54: 399) and *D. nigricolor* Strobl (1898. Mitt. Naturwiss. Ver. Steiermark (1897). 34:266). I propose *Drosophila picea* Hardy as the new name for *D. nigricolor* Hardy.

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